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(54) Abstract Title
Vehicle anti-theft system whereby a transponder carried by the user communicates with antennae of the car

(57) Two or more antennae 3 disposed in a vehicle 1 are controlled with a pulse-width modulated rectangular signal by a power control unit and a phase control unit. If the transponder 5 is orientated so that the signal received from the antennae is not strong enough to challenge the transponder, the phase and/or the transmitting power of the antennae may be altered so that the three-dimensional intensity distribution of the induced magnetic field 4 is changed. This may result in a stronger signal being received at the transponder. The power and phase are controlled such that power alteration does not cause a phase alteration and vice versa. On receiving the challenge signal from the antennae, the transponder emits an item of encoded information in a response signal. The control unit 2 compares the received response values with an expected value stored and for example releases door locks 7 or the immobiliser 8 upon successful authentication.

FIG 1

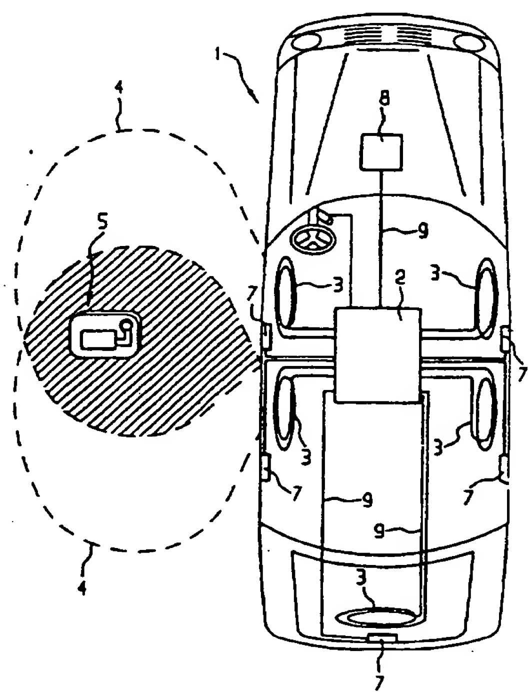

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FIG 1

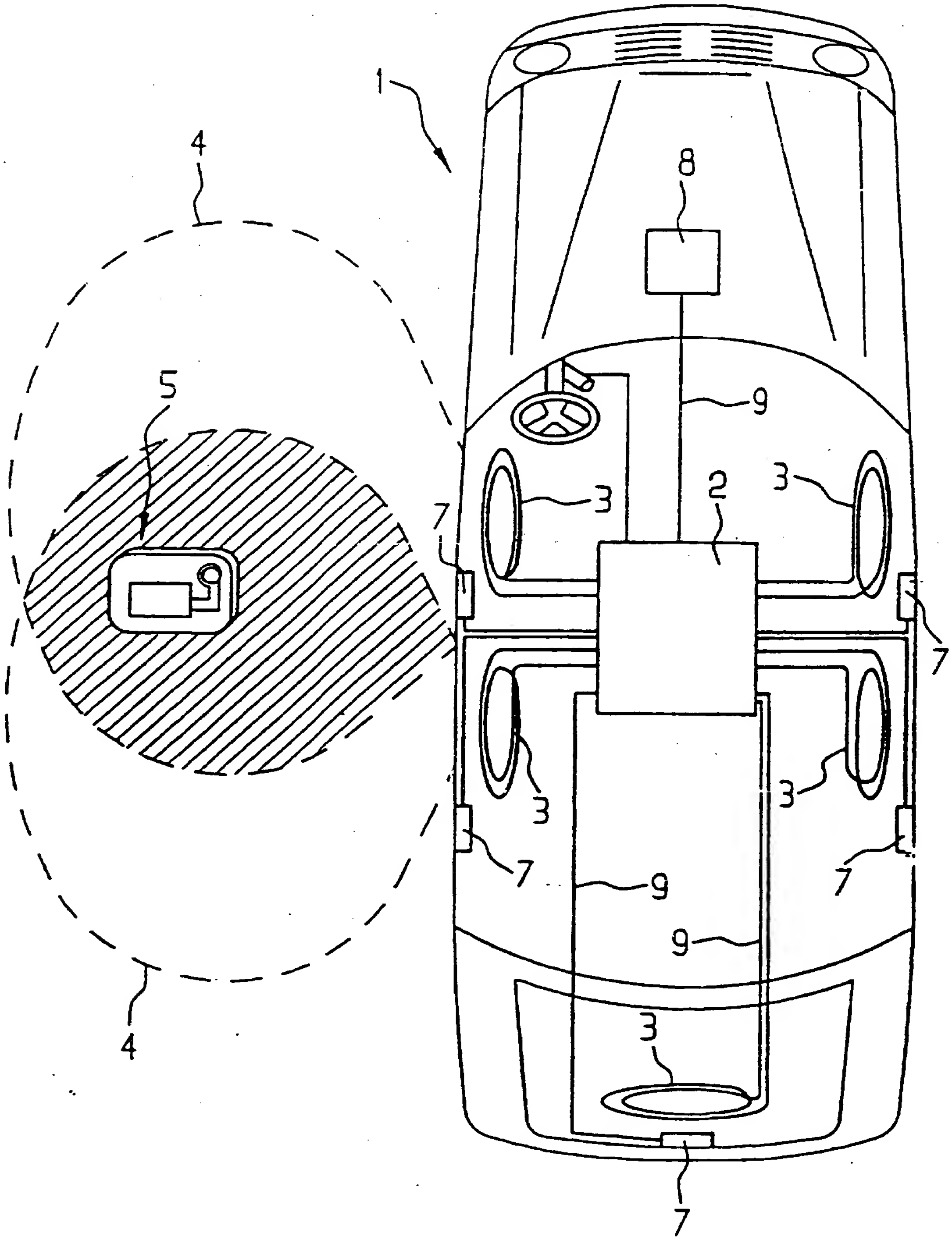


FIG 2

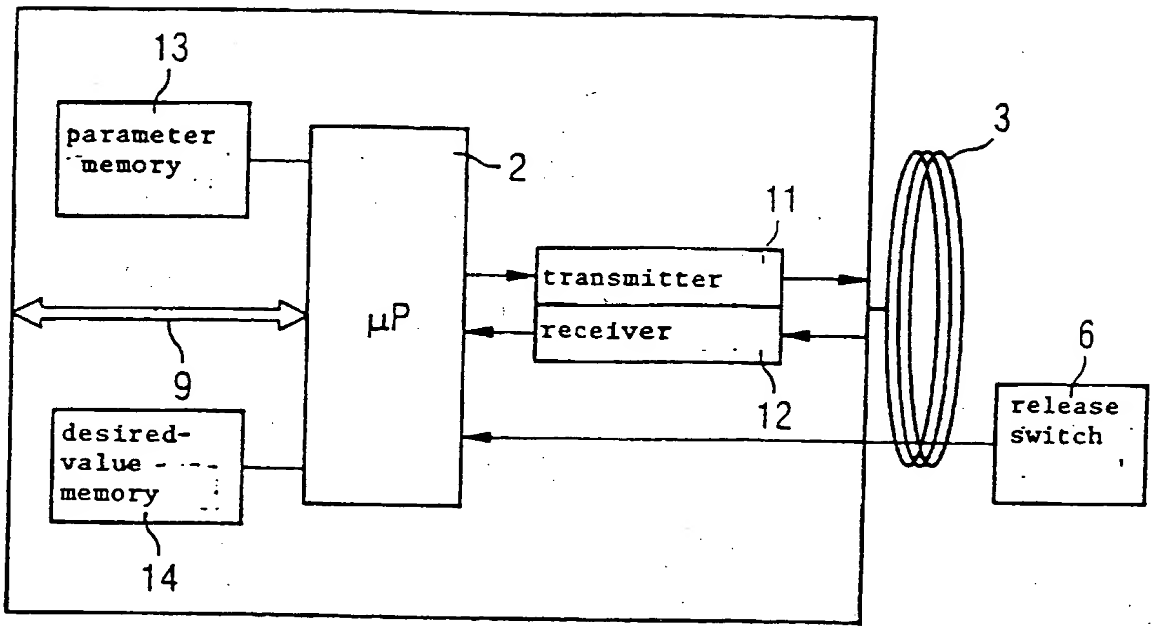

13
parameter memory
2
μP
3
11
transmitter
receiver
12
9
6
release switch
desired-value memory
14

FIG 3

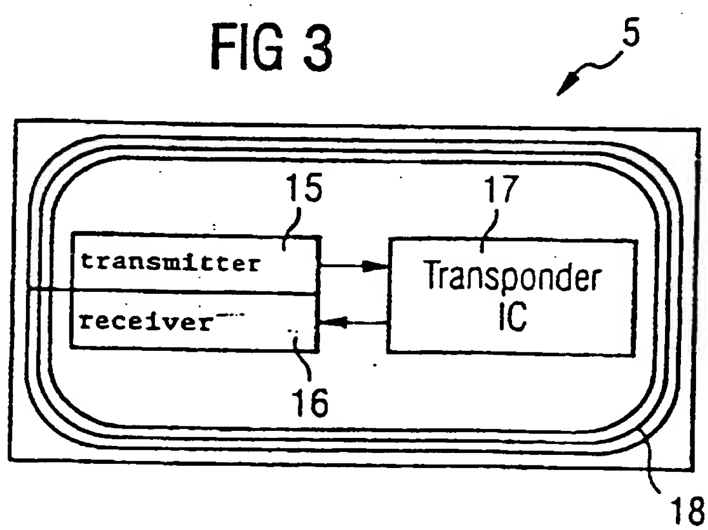
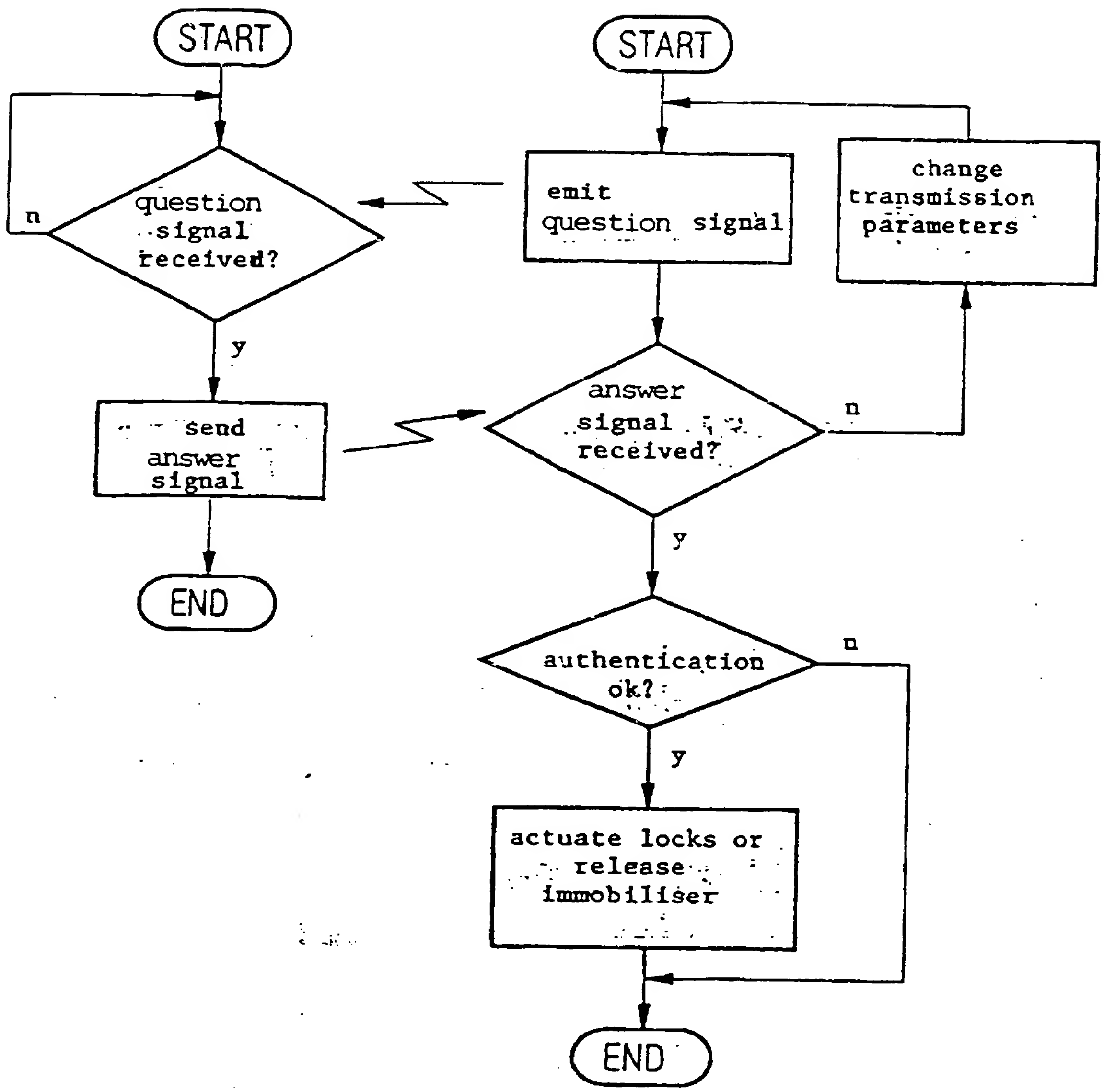
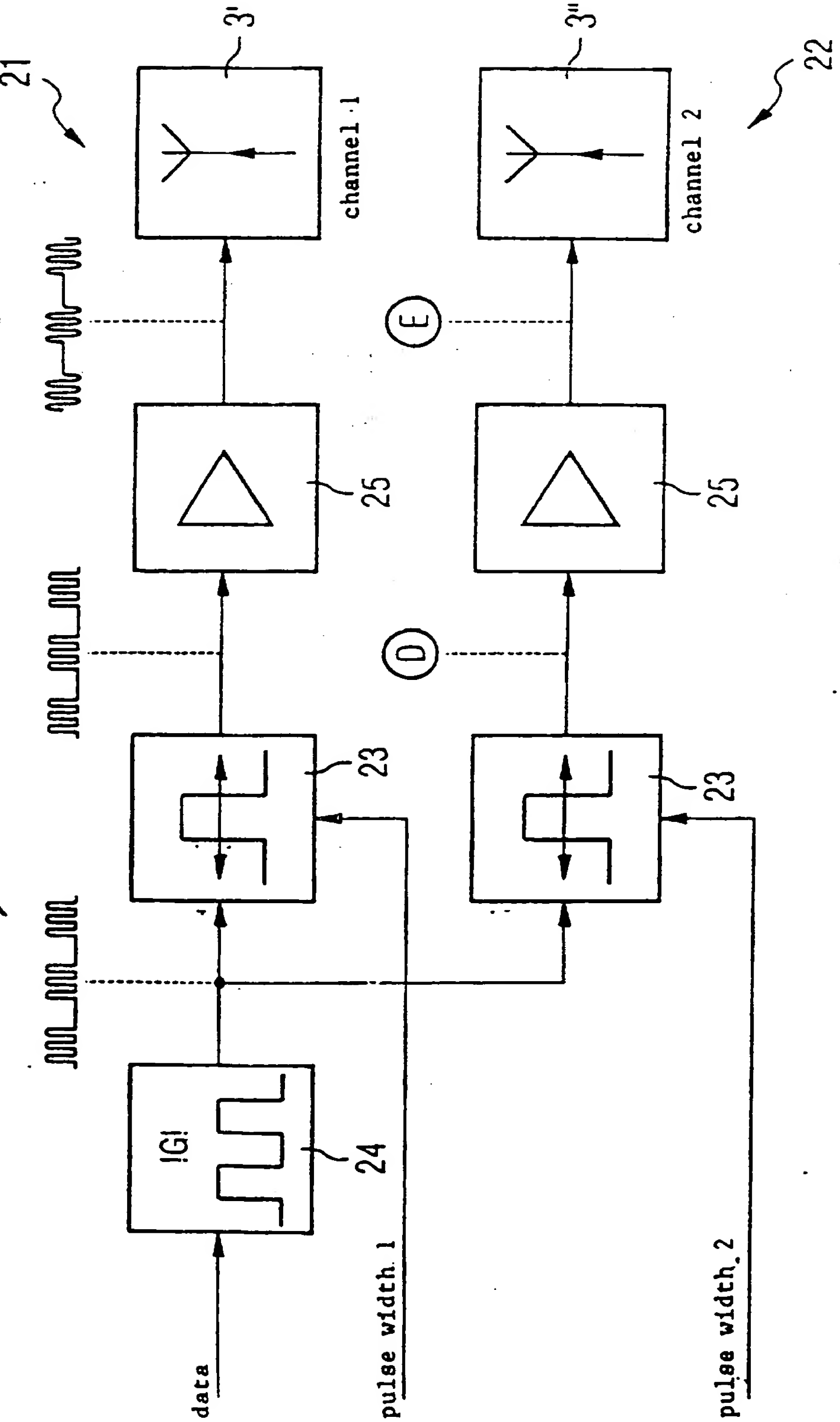

5
15
17
transmitter
receiver
Transponder IC
16
18

FIG 4


START
question signal received?
n
y
send answer signal
END
START
emit question signal
change transmission parameters
answer signal received?
n
y
authentication ok?
n
y
actuate locks or release immobiliser
END



data
pulse width 1
pulse width 2
!G!
24
20
A
23
B
25
C
D
E
3'
3''
21
22
channel 1
channel 2

FIG 5

FIG 6A
FIG 6B
FIG 6C
FIG 6D
FIG 6E

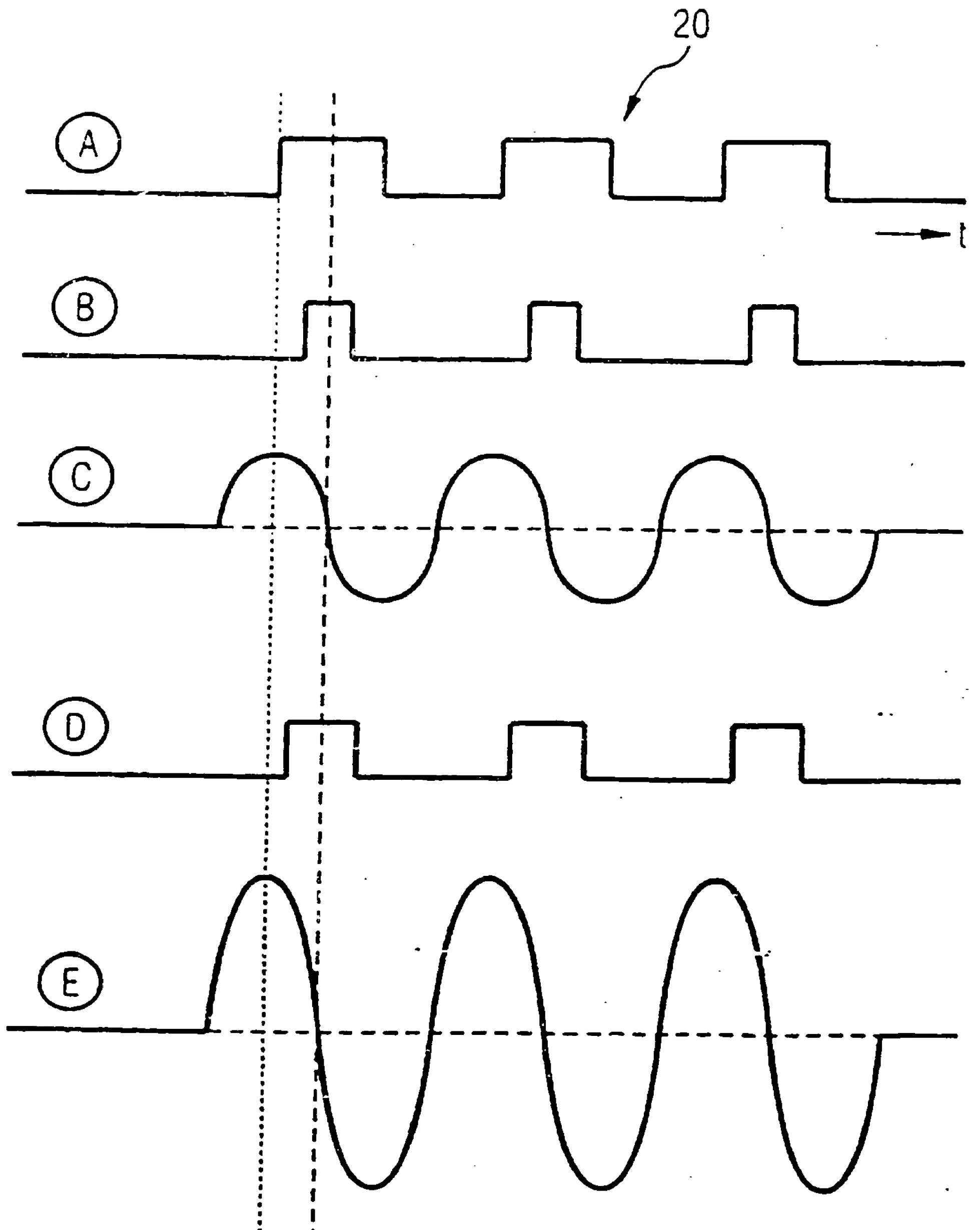


FIG 7

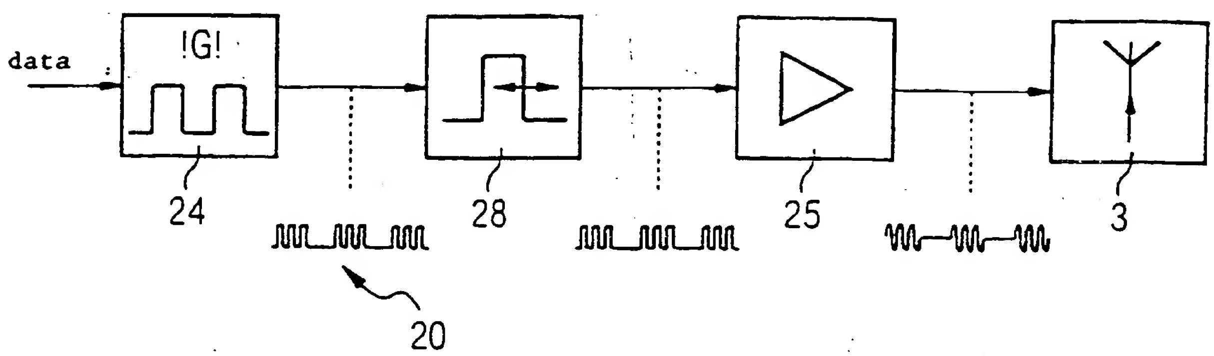


FIG 8

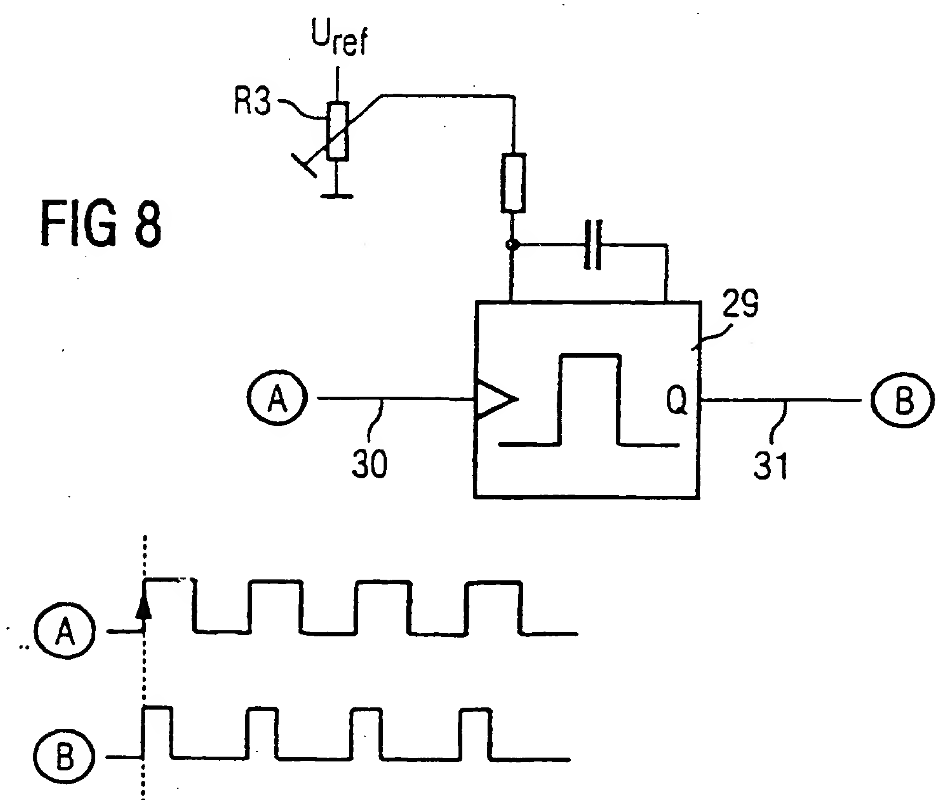


FIG 9

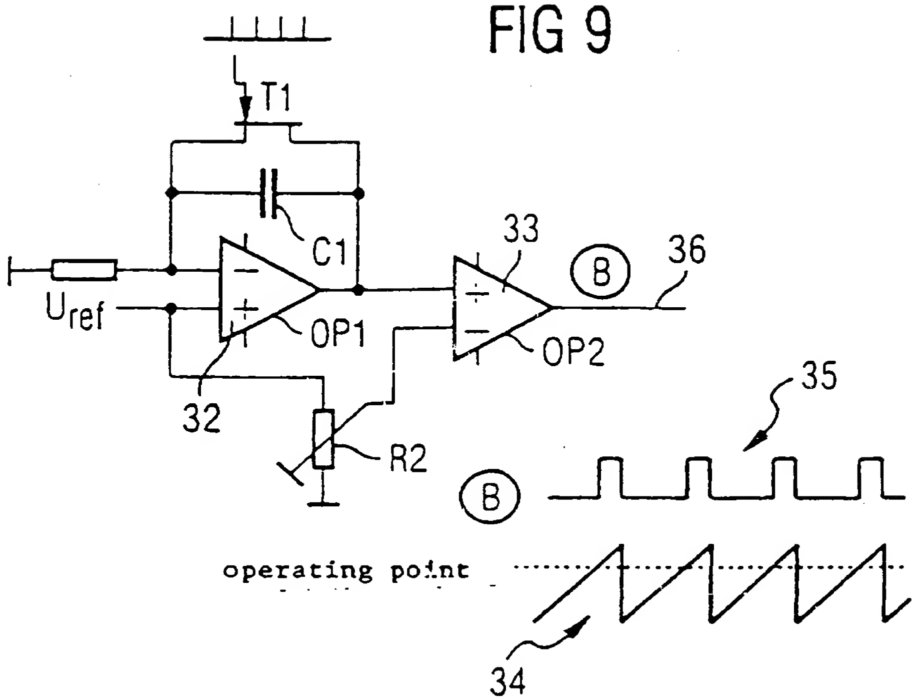

T1
C1
33
36
B
Uref
OP1
OP2
32
R2
35
B
operating point
34

FIG 10

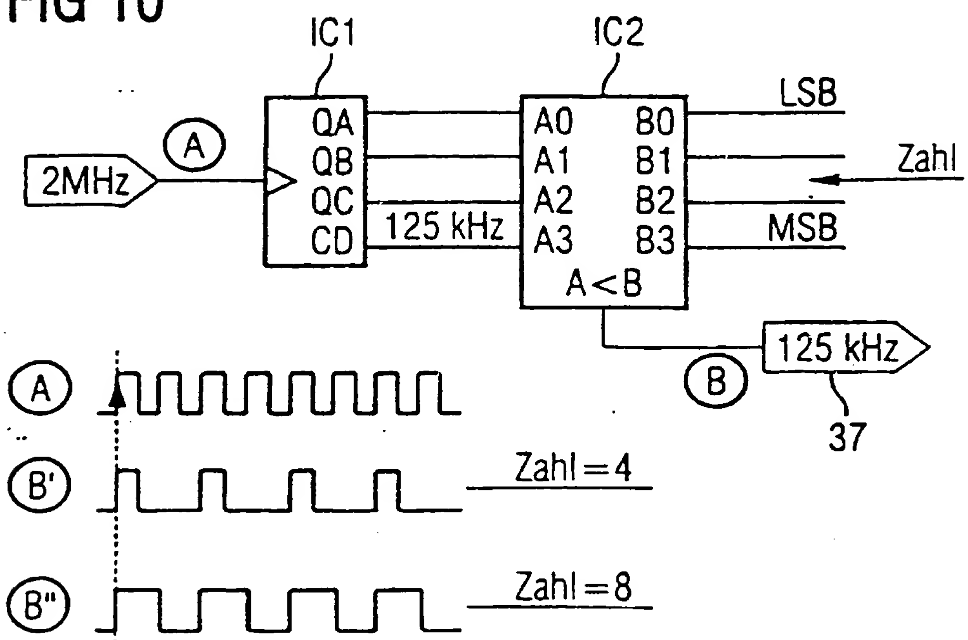
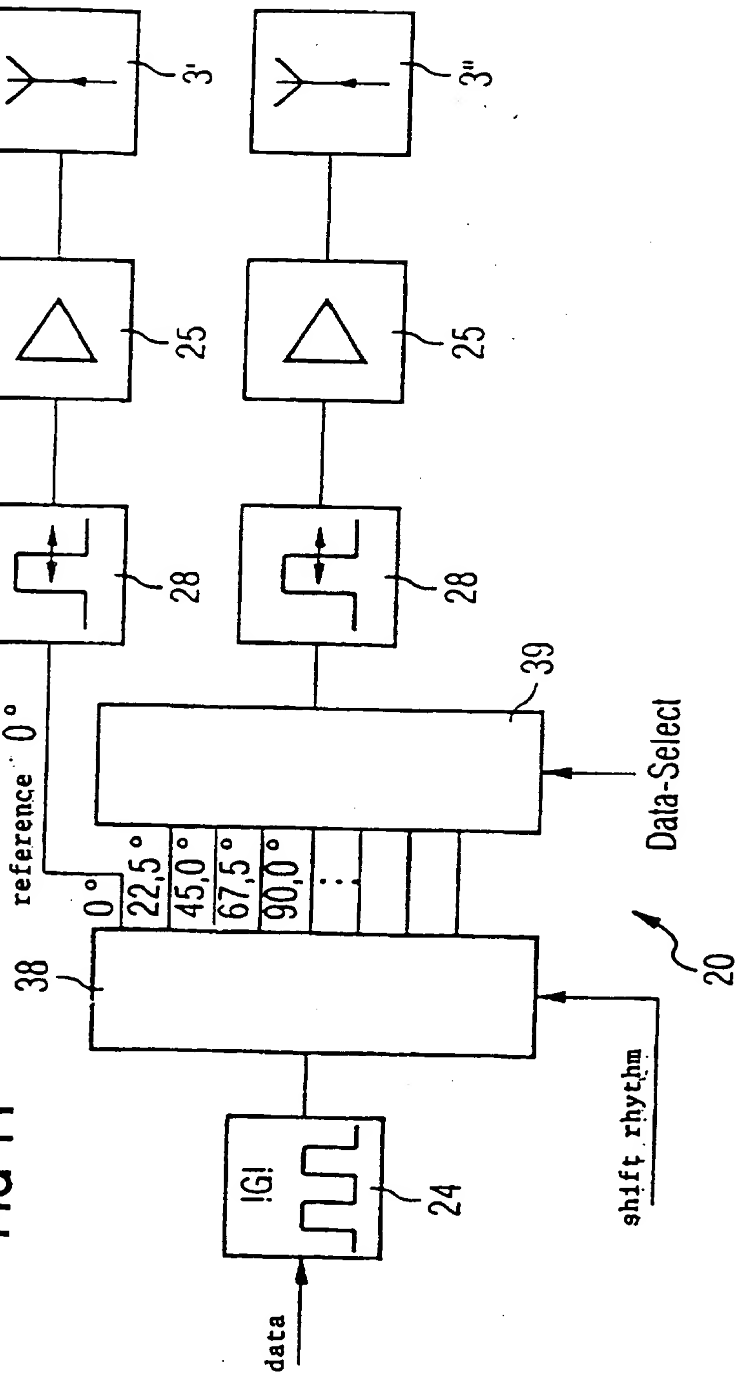

IC1
IC2
LSB
QA
QB
QC
CD
A0
A1
A2
A3
B0
B1
B2
B3
2MHz
A
Zahl
125 kHz
MSB
A<B
125 kHz
B
37
A
B'
Zahl=4
B"
Zahl=8

FIG 11


3'
3"
25
25
28
28
39
Data-Select
reference 0°
0°
22,5°
45,0°
67,5°
90,0°
38
20
!G!
24
shift rhythm
data

Anti-theft system for a motor vehicle

The invention relates to an anti-theft system for a motor vehicle, in which doors are locked or unlocked or an electronic immobiliser is released only after verification of an authorisation.

An anti-theft system known from DE 38 02 248 A1 has an antenna device in the driver's door. When a user wants to get into the vehicle, a challenge-response dialogue is triggered by actuation of a release switch. In this connection, a challenge signal is sent by the antenna device in the vehicle to a transponder carried by the user. The transponder sends back an encoded response signal if it receives the challenge signal. In the motor vehicle, the response signal is compared with an expected desired signal and if the two agree (successful authentication), the doors are locked or unlocked.

Such an antenna device is realised by two frame antennae which are at right angles to each other. Electromagnetic fields are generated by the antennae. These fields induce a voltage in a transponder coil of the transponder. In order that the induced voltage is as high as possible, the field lines must permeate the transponder coil to a sufficient degree. This is the case if the field lines of the magnetic field which is generated extend not in one plane but instead in at least two planes. Therefore, the two frame antennae are there arranged at right angles to each other. This, however, requires a large amount of installation space.

It can, however, happen that the turn area of the transponder coil of the portable transponder is by chance positioned in such a way that the turn area still extends in parallel with the field lines of the magnetic field. The magnetic field then does not permeate the transponder coil or does not do so

sufficiently, so that the challenge signal is not received by the transponder, or is received with too low an amplitude.

In the anti-theft system known from DE 195 42 441 A1, there is used an antenna which comprises two frame antennae, which are arranged close together and in one plane. In order to generate a three-dimensional magnetic field, the two frame antennae are controlled separately from each other, but in a manner such that they are out of phase with respect to each other. There thus results a magnetic field which is moved to and fro in a three-dimensional manner. Here as well, it is still possible that magnetic field lines of the magnetic field generated by the two frame antennae do not permeate the turn areas of the transponder coil to a sufficient degree.

Apart from this, the two frame antennae can not always be arranged close together. This is, for example, the case if one frame antenna is arranged in the front door and the other in the rear door. A magnetic field which moves to and fro is then not produced - or a magnetic field which is only slightly distinct results - because the range of the magnetic field is restricted.

The invention seeks to develop a new anti-theft system for a motor vehicle. In particular, the present invention seeks to provide an anti-theft system for a motor vehicle in which anti-theft system signals are emitted by a vehicle-side transmitter in such a way that they can be reliably received by a portable transponder in the vicinity of the motor vehicle, and this occurs substantially independently of the form of the transponder.

According to the present invention, there is provided an anti-theft system for a motor vehicle comprising:

a transmitting and receiving unit which is arranged in the motor vehicle and is electrically connected to at least two antennae, which are arranged separately from each other in the motor vehicle and by way of which a respective signal is emitted or received;

a control unit, which is part of the transmitting and receiving unit and controls the antennae for transmitting and receiving signals and also evaluates the signals which are received, with a signal being supplied to at least two antennae in each case; and

a power control unit and a phase control unit by which the transmitting power and the phase of the signals are controlled in such a way that no unwanted effects on the phase and transmitting power, respectively, occur.

The present invention also provides a motor vehicle incorporating the anti-theft system of the invention.

In this connection, at least two antennae are arranged separately from each other in the motor vehicle. By way of the antennae, two signals are emitted which differ in terms of their phase with respect to each other and in terms of their transmitting power, in which case an alteration of the transmitting power does not effect an unwanted alteration in the phase and vice versa. This is effected by a power control unit and a phase control unit. An item of information contained in the signals is not altered by alterations to phase and transmitting power.

In this way, there results a superposed magnetic field, the directional characteristic of which is dependent on the transmitting power and the phase of the signals of each antenna. If the transmitting power and/or the phase of the signals is deliberately

altered, magnetic fields result which have altered in terms of their three-dimensional intensity distribution with respect to the preceding magnetic fields. As a result, the transponder can receive, even under unfavourable conditions, a sufficiently large signal, on the basis of which it can send back its response signal.

Advantageous developments of the invention are set out in the subclaims. The values of the transmitting powers and the phases of the signals can therefore be stored as transmission parameters. The transmission parameters can also be systematically varied so that a challenge signal is still received by the transponder even if first of all no signal was received.

For a better understanding of the present invention, and to show how it may be brought into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows a block-circuit diagram of an anti-theft system in accordance with the invention;

Figure 2 shows a block-circuit diagram of a transmitting and receiving unit of the anti-theft system according to Figure 1;

Figure 3 shows a block-circuit diagram of a portable transponder of the anti-theft system according to Figure 1;

Figure 4 shows a flow chart of a process for an authentication with the aid of the transponder;

Figure 5 shows a detailed block-circuit diagram of two transmitting and receiving channels of the anti-theft system;

Figures 6a to 6e show signal characteristics inside the transmitting and receiving unit;

Figure 7 shows a block-circuit diagram of a power control unit;

Figures 8 to 10 show exemplary embodiments of

circuit arrangements of a power control unit; and

Figure 11 shows an exemplary embodiment of a circuit arrangement of a phase control unit.

An anti-theft system in accordance with the invention for a motor vehicle 1 is shown in Figure 1 and has a vehicle-side transmitting and receiving unit having a control unit 2 and antennae 3. The transmitting and receiving unit emits radio signals via the antennae 3. Likewise, signals are received via the antennae 3 and evaluated in the control unit 2.

The control unit 2 is connected to a plurality of antennae 3, which may be arranged, for example, in the driver's door, the front passenger door, the rear doors, on the body/luggage compartment, in the region of the fuel tank, in the region of the bumper or in other places, in a manner such that they are distributed over the motor vehicle 1. In this connection, the signals are emitted via at least two antennae 3, with each antenna 3 generating an electromagnetic field. The magnetic fields are superposed and thereby form a three-dimensional superposed magnetic field. A directional characteristic 4, and thus the range of the superposed magnetic field, thereby depends on the transmitting power of the individual antennae 3 and the phase between the signals which are emitted via the two antennae 3.

If a person desires access to the motor vehicle 1, they must first of all identify themselves with the aid of a portable code transmitter (called transponder 5 in the following). As soon as the user who desires access to the vehicle actuates a release switch 6 (see Figure 2), a signal (called challenge signal in the following) is emitted via the antennae 3. If the challenge signal is received by the transponder 5, the latter in turn sends back an item of encoded information in an

response signal.

The response signal is received by the antennae 3 in the motor vehicle and supplied to the control unit 2 as evaluation unit. There, the response signal is evaluated. The control unit 2 is connected to door locks 7, control units (in particular an immobiliser control unit 8) or other electronic units in the motor vehicle 1, by way of data lines 9. If the transponder 5 proves to be authorised (successful authentication), then, depending on the content of the response signal, one or all door locks 7 are locked or unlocked, the immobiliser control unit 8 is released, the interior light is switched on/off, windows or sun-roof are opened/closed, the heating is switched on/off, etc. For this purpose, control signals are sent out to the corresponding electronic units in the motor vehicle 1 by way of the control unit 2.

In accordance with Figure 2, the transmitting and receiving unit has the control unit 2 which can, for example, be constructed as a micro-processor μP. The control unit 2 controls the transmitting and receiving of signals, evaluates the signals which are received, and controls further electronic units in the vehicle. For this purpose, the said control unit is connected to at least one transmitter 11 (Figure 2) and one receiver 12 in which the signals are modulated or demodulated. Each antenna 3 is in turn connected to a respective transmitter 11 and a receiver 12. Signals can also be received via other antennae, which are not shown.

The control unit 2 is connected by way of the data line 9, or by way of a bus line, to the door locks 7, the immobiliser control unit 8 or other control units. The transmitting and receiving unit also has memory units (parameter memory 13 and desired-value memory 14) in which transmission parameters and items of desired information are stored.

With the stored transmission parameters, the control unit 2 receives the information about the phase and the power or amplitude with which the signals are to be emitted or were previously emitted. For the purpose of authentication, the stored items of desired information are compared with the received, encoded information which is contained in the response signal. As a result of this, the authorisation of the user is therefore checked.

The transponder 5 is advantageously arranged on a cheque-card-size card. It has a transmitter 15 (Figure 3) and a receiver 16, which are connected to a transponder-IC 17. With the transponder-IC 17, an item of desired code information, which is protected from unauthorised access and is specific to the user, is stored, or such an item of information is generated there with the aid of a secret mathematical algorithm.

The item of code information is transmitted to the motor vehicle 1 in encoded form in the response signal if a challenge signal has previously been received.

In order to transmit and receive signals, the transponder 5 has an antenna in the form of a coil (transponder coil 18). When signals are received, a voltage is induced in this transponder coil 18 if the transponder coil 18 is located inside the range of a magnetic field (see Figure 1) and permeated by enough field lines, i.e. if the magnetic field in the region of the transponder coil 18 is sufficiently large.

The process of authentication is explained in greater detail with the aid of Figure 4. In this connection, in Figure 4, the process steps which take place in the transponder 5 are shown on the left-hand side and the process steps which take place in the transmitting and receiving unit of the motor vehicle 1 are shown on the right-hand side.

First of all, a challenge signal is emitted by the

motor vehicle 1 via at least two antennae 3. If a challenge signal is received by the transponder 5, the response signal is sent back by the transponder 5. If the response signal is not received within a specified period of time, the transmission parameters are systematically altered (according to a pattern which is decided in advance). As a result of the altered transmission parameters, the directional characteristic 4 and the three-dimensional distribution of the superposed magnetic field are altered as a result of altered transmitting power and/or phase of the signals which are emitted. After this, the challenge-response dialogue is carried out again.

If the response signal has been received by the vehicle-side transmitting and receiving unit, the item of code information contained therein is compared with the expected item of desired code information. If the authentication has been successful (code information is same as desired code information), door locks 7 are unlocked or the immobiliser is released. For this purpose, at least one control unit which is necessary for the operation of the motor vehicle, such as the engine control unit, is put into operation in accordance with the regulations by the immobiliser control unit 8.

If the authentication was not successful, the process of authentication is ended. If appropriate, an alarm can be triggered if an attempt has been made to carry out the authentication with an unauthorised transponder 5.

The challenge signal is emitted via at least two antennae 3 in the motor vehicle 1. Since the antennae 3 are constructed as coils, high-frequency magnetic fields are generated which, depending on the position of the antennae 3, the external shape of the antennae 3 and depending on the intensity distribution of the

individual magnetic fields of each antenna 3, are superposed (see shaded region in Figure 1).

The antennae 3 emit signals which differ in terms of their transmitting frequency, transmitting power and/or their phase with respect to each other. As a result of deliberate alterations to one of the above-mentioned parameters, the directional characteristic 4 of the field and the local intensity distribution are altered. As a result of this, the resulting magnetic field (superposed magnetic field) is three-dimensionally altered.

By systematic alteration of the transmission parameters, it is thus possible to ensure that the transponder 5 is reliably acted upon at least once. If a user wants to get into the vehicle, they must first of all trigger the challenge-response dialogue. Depending on where the user carries the transponder 5 and how the turn area of the transponder coil 18 is aligned with respect to the magnetic field lines of the magnetic field generated by the antennae 3 in the motor vehicle 1, the challenge signal can be received with varying intensity.

If the transponder coil 18 of the transponder 5 is aligned in such a way that the magnetic field lines of the magnetic field which is generated cut the transponder coil 18 perpendicularly (turn area at right angles to the magnetic field lines), then, in a known way, the highest voltage is induced in the transponder coil 18. The challenge signal is therefore optimally received.

If, however, the transponder coil 18 is aligned in such a way that the magnetic field lines extend in parallel with the turn area of the transponder coil 18, no voltage is induced in the transponder coil 18. The challenge signal is then not received, even though the transponder is located sufficiently close to the motor

vehicle 1 and within the range of the antennae 3. It can likewise arise that there are local regions in the superposed magnetic field in which the field has a only very low intensity, so that the challenge signal cannot be received, or is received with too low an intensity.

If the challenge signal is still not received in certain regions even though the range of the magnetic field must be sufficient, such a case is explained by a local zero point. A transponder 5 is located in a zero point if the intensity of the voltage induced in the transponder coil 18 lies below a threshold value.

The positions of the zero points depend on various parameters, such as, on the one hand, the position or orientation of the transponder coil 18, but also, on the other hand, the position in which the antennae 3 are mounted in the vehicle 1, the external shape of the antennae 3, the transmitting power or amplitude and the phase of the signals of two antennae 3 with respect to each other.

In order also to detect a transponder 5 which is arranged in a zero point, the antennae 3 are triggered one after the other, in a manner such that they differ with respect to transmitting power and phase. If a signal is emitted via two antennae 3, there results for each antenna 3 an alternating magnetic field, which is superposed with the alternating magnetic field of the other antenna 3. By altering the individual fields, there result one after the other different superposed magnetic fields, the three-dimensional intensity distribution of which is dependent on the transmission parameters (here transmitting power and phase; the transmitting power in the case of uses in automotive engineering is constantly at 125 kHz).

The systematic alterations in the transmitting power and the phase go unnoticed by the user, and take place if first of all no response signal is received.

Afterwards, the challenge signal is generated under altered magnetic field conditions (other transmission parameters) and an response signal is again awaited.

In the anti-theft system, a carrier oscillation of, for example, 125 kHz is modulated with an item of binary encoded information or code information (Figures 5 and 6A) of 2 kHz, for example. The antennae 3 are therefore controlled with binary encoded signals (rectangular signals 20 with a mark-to-space ratio which is determined by the encoded information), by which a corresponding oscillation is generated in the antennae 3. The encoded information is contained in the envelope curve of the rectangular signals 20.

If the power or amplitude of the rectangular signals 20 is altered, the phase of the signals which are emitted is also altered to a greater or lesser extent as a result, and vice versa. The binary information contained in the rectangular signals 20 is not, however, altered.

In order to obtain a defined intensity distribution in the superposed magnetic field, the transmitting power is altered in accordance with the invention, in such a way that it has no unwanted influence on the phase, and vice versa. The transmitting power is therefore adjusted, and the phase is simultaneously corrected in such a way that it remains constant, and vice versa.

A block-circuit diagram of transmission channels 21, 22 of the transmitting and receiving unit having a pulse control unit 23 (symbolised by a double arrow over the rising edge and falling edge) is shown in Figure 5. In this connection, there is supplied to an oscillator 24, by the control unit 2, data which contains the binary code information to be transmitted. In the oscillator 24, a modulation with a high-frequency carrier takes place. At the output of the

oscillator 24, the corresponding rectangular signal 20 is available, in the envelope curve of which the binary code information is contained. With this rectangular signal 20 - according to the exemplary embodiment according to Figure 5 - two antennae 3′ and 3′′ are controlled in order to emit the binary code information (challenge signal).

The pulse control unit 23 is arranged downstream of the oscillator 24. The rectangular signal 20 is controlled in terms of its amplitude and phase by this pulse control unit. The alteration of the amplitude and/or the phase is - as explained in greater detail below - controlled by altering the pulse width of the individual pulses of the rectangular signal 20. The pulse control unit 23 receives the values for the pulse widths from the control unit 2.

The rectangular signal 20, which is altered in terms of amplitude and/or phase, is supplied to the two antennae 3′ and 3′′ by way of an output stage 25. Each antenna 3 is part of an LC oscillating circuit. If such an oscillating circuit is incited to oscillate by a rectangular signal, it oscillates in the form of a pulsed sinusoidal signal, the binary code information still being contained in the envelope curve of this sinusoidal signal.

The antennae 3′ and 3′′ are arranged in parallel with each other and are connected to the control unit 2 by way of the oscillator 24. Each branch in which an antenna 3′ or 3′′, an output stage 25 and a pulse control unit are located, is designated transmission channel 21, 22.

Figures 6a to 6e show signal characteristics from the circuit arrangement according to Figure 5. Figure 6a shows the basic pattern of the binary code information, namely the rectangular signal 20. The code information is emitted as a challenge signal via

the antennae 3. In order to shape the superposed magnetic field in an appropriately three-dimensional manner, the challenge signal is sent over the two transmission channels 21 and 22 with different transmitting power/amplitude and phase. As a result of this, it is already achieved that the zero points are shifted with respect to a challenge signal which is emitted with the same transmission parameters, in such a way that the said zero points probably do not lie in the region of the possible location in which the transponder 5 is held.

The binary code information is now, for example, emitted via the antenna 3' in the first transmission channel 21 with low amplitude and in the second transmission channel 22 with high amplitude. The phase between the two signals must, however, remain unaltered for the time being.

The control unit 2 now sets a narrow pulse width for the pulse control unit 23. The signal at the output of the pulse control unit 23 of the first transmission channel 21 then - in accordance with Figure 6b - has narrow pulses. The pulse control unit 23 then also ensures that the phase of the signal remains unaltered with respect to the centres of the pulse and is isochronous with each pulse rise of the binary code information (compare Figures 6A and 6B). As a result of the narrow pulse width - as explained in greater detail below - there is generated downstream of the output stage 25 of the first transmission channel 21 a sinusoidal oscillation (Figure 6c) which has a low amplitude. The binary code information is still contained in the envelope curve thereof.

The pulse control unit 23 of the second transmission channel 22 receives a large pulse width as an input from the control unit 2. As a result of this, the pulses (Figure 6d) are widened at the output of the

said pulse control unit, as a result of which a higher amplitude (Figure 6e) of the sinusoidal signal downstream of the output stage 25 of the second transmission channel 22 is obtained. The phase of these pulses is again kept constant in such a way that the pulse centre is isochronous with each pulse rise in the binary code information (compare Figures 6A and 6D). The pulse width is therefore altered and at the same time its instant of rise is shifted with respect to time. In this way, the phase is not altered in either of the two transmission channels 21 and 22, even if the amplitude, and thus the transmitting power, is different.

Because the antenna 3 is part of an LC oscillating circuit, a proper oscillation is achieved only if - as in the case of a pendulum - the energy which is supplied has the same direction as the deflections of the oscillation themselves, because otherwise an escalation of the oscillation cannot take place. In this connection, the supply of energy within a period can take place continuously or intermittently, i.e. for a comparatively short time to a recurrent fixed starting point. If the force is equally great in both cases, a large and a small oscillation result, owing to the different current flow times. The question is now how to determine the starting point for the energy flow in both cases in order that the resulting oscillations - seen with respect to time - coincide.

An oscillation naturally oscillates symmetrically about a zero line. The zero crossing of the oscillation simultaneously represents the starting point for the supply of energy in both directions. The directions are characterised by a change of sign, in which case the current flow between the coil L and the capacitor C of the LC oscillation circuit is reversed.

In the case of a narrow pulse width, in which the

centre of the pulse coincides with the zero crossing of the oscillation, a small oscillation is generated. If the pulse is wider, more energy is supplied to the oscillation, and an oscillation having a higher amplitude is generated. If the rising edge in the case of a widened or shortened pulse width is now adjusted in terms of its phase by the pulse control unit 23 in such a way that the pulse centre coincides with the zero crossing of the oscillation, the amplitude is altered, but the phase of the oscillation is not.

In this way, the amplitude of an oscillation can be altered simply without this having an effect on the phase of the oscillation. If the phase is now to be altered, the pulsed signal can be delayed with respect to time, i.e. the instant of the rising edge and falling edge has to be shifted by the same amount. This has no influence on the amplitude, because no more energy is put into the circuit. The amplitude does not, therefore, need to be re-adjusted. In this way, a phase alteration still has no influence on the amplitude.

The realisation of such a pulse control unit 23 is shown in Figures 7 to 11, the pulse control unit 23 being divided into a phase control unit 27 and a power control unit 28. In Figures 8 to 10, on the circuit arrangements which are shown, corresponding signal characteristics inside the circuit arrangements are also shown.

Figure 7 shows only the power control unit 28 (symbolised with a double arrow over only the falling edge of the pulse) of the transmission channel 21. By this control unit, the pulse width is altered in order that a higher or lower amplitude of the oscillation is generated. Without the phase control unit 27, this automatically entails an alteration in the phase, something which, however, is prevented in accordance

with the invention with the aid of the phase control unit 27.

In the following, first of all only the power control unit 28, without the phase control unit 27, is taken into consideration. The power control unit 28 can, in accordance with Figure 8, be realised in analog form with the aid of a mono-stable flip-flop 29. The mono-stable flip-flop 29, which is triggered with a constant frequency, outputs the desired mark-to-space ratio (ratio of pulse width to interpulse period) by appropriately adjusting the current (rectangular signal 20) at its input 30 with the aid of a resistance R3. The desired rectangular signal 31' is then available at its output 31.

Alternatively, a ramp generator 32 (Figure 9) can also be used together with a comparator 33 to alter the pulse width. In this connection, needle pulses of a constant frequency cyclically discharge an integration capacitor C1 by way of a transistor T1. As a result of this, there is formed at the output of the ramp generator 32 (realised as operational amplifier OP1) a saw-tooth voltage 34, which is supplied to the comparator 33 (realised as operational amplifier OP2). The switching threshold of the comparator 33 is an adjustable direct voltage, which is adjusted with a resistance R2. On the basis of this switching threshold, the desired mark-to-space ratio of the rectangular signal 35 at the output 36 of the comparator 33 is then produced. This output signal is then supplied to the output stage 25.

The power control can likewise be carried out digitally - as shown in Figure 10. A binary value of an up-counter IC1 which operates with constant frequency is supplied to a 4-bit comparator IC2. There is applied to second inputs of the comparator IC2 an adjustable comparison value (a number from 1 to 8), by

which the desired mark-to-space ratio of the rectangular signal is specified (corresponds to the transmission parameter which is delivered by the control unit 2). By comparing the magnitude of the input values at the inputs A and B, the desired mark-to-space ratio is obtained at the output 37 (A<B) of the comparator IC2. The mark-to-space ratio is represented once for the number "4" (C') and once for the number "8" (C'').

In accordance with Figure 11, the phase control unit 27 can be realised with the aid of a shift register 38 and a demultiplexer 39. All transmission channels 21, 22 are linked by way of the 8-bit shift register which is used here. The rectangular signal is present with different phases (0°; 22.5°; 45°; etc) at the output of the shift register 38. As a result of appropriate selection of the phase angle, there is supplied to the second transmission channel 22 - in the exemplary embodiment according to Figure 11 - a desired output of the demultiplexer 39 and thus the desired phase angle. In comparison with the first transmission channel 21, which is controlled with the reference angle 0°, the signal in the second transmission channel 22 then has the desired phase. Subsequently, the desired power can be set in the power control unit 28.

The pulse-width control described above for establishing the power and the phase can also be realised as a push-pull control. In this connection, energy is supplied to the oscillation circuit in both a positive and a negative half-wave. For this purpose, either a full bridge circuit (not shown) or a half-bridge circuit can be supplied with positive and negative supply voltage. In this connection, the individual switches of the bridge circuits are switched on and off in a time-controlled manner, so that corresponding pulse-width modulated signals result,

with which the oscillating circuit is incited to oscillate. Full bridges and half bridges are already known per se and therefore do not need to be explained in greater detail.

As a result of the anti-theft system in accordance with the invention, the positions of zero points are, by different triggering, avoided or shifted in terms of their three-dimensional position so that they no longer lie in the region of the transponder 5 but a successful authentication can still take place. The zero points can then be shifted in a reproducible and defined manner if the power and the phase of the signals are controlled in such a way that a power alteration does not result in a phase alteration and vice versa, i.e. the mutual influence of the power control unit 28 and the phase control unit 27 is effectively controlled.

The values for the transmission parameters at which a successful authentication has taken place can be stored and used as starting values in the following authentication processes. As a result of this, the probability is increased that only one authentication process has to be carried out. Consequently, the process of authentication is shortened. The transmission parameters can also be systematically altered, preferably in specified stages, so that the superposed magnetic field is clearly altered in terms of its three-dimensional intensity distribution.

The anti-theft system in accordance with the invention has the advantage that it can be used in very different motor vehicles. The anti-theft system does not then have to be matched to the geometry (long version, short version), degree of fitting (sun roof, folding top, etc) and materials used (aluminium, magnesium alloys). Even component tolerances and temperature alterations have little influence on the successful authentication, because the superposed

magnetic field is altered by the transmission parameters and then always reliably reaches a transponder, even if the transponder is in an initial zero point. The zero point is three-dimensionally shifted or completely eliminated by altering the transmitting power and/or the phase. After this, the transponder 5 should be able to receive the challenge signal successfully and send back its response signal. If it does still not receive the challenge signal, the transmission parameters have to be changed again.

With the power control unit 28 and the phase control unit 27, a control of the transmitting power and the phase that is as loss-free as possible can be carried out, because an intermittent signal (rectangular signal) is used for the control. A plurality of antennae 3 can also be controlled independently of each other.

With the anti-theft system, the ranges of the individual antennae 3 can be adjusted in such a way that a reliable inside-space recognition and outside-space recognition of the transponder 5 is possible. The range and the directional characteristic 4 can be adjusted in such a way that the challenge signal cannot be received outside the motor vehicle 1 (inside-space recognition) if the transponder 5 is to be recognised only in the inside space, and vice versa.

If the transponder 5 is recognised outside (i.e. it sends back its response signal), access is released by unlocking one or all doors. If the transponder 5 is correctly recognised in the inside space, the immobiliser is released and the user can drive away with the motor vehicle 1. In the case of locking, the transponder 5 must again be recognised in the outside space, because otherwise there is the danger that it will get locked inside the vehicle.

Claims

1. Anti-theft system for a motor vehicle comprising:

a transmitting and receiving unit which is arranged in the motor vehicle and is electrically connected to at least two antennae, which are arranged separately from each other in the motor vehicle and by way of which a respective signal is emitted or received;

a control unit, which is part of the transmitting and receiving unit and controls the antennae for transmitting and receiving signals and also evaluates the signals which are received, with a signal being supplied to at least two antennae in each case; and

a power control unit and a phase control unit by which the transmitting power and the phase of the signals are controlled in such a way that no unwanted effects on the phase and transmitting power, respectively, occur.

2. Anti-theft system according to claim 1, wherein the power control unit and the phase control unit control the pulse width of the signals.

3. Anti-theft system according to one of the preceding claims, wherein each antennae, in the form of electric coils and as part of an LC oscillating circuit, is arranged in one of the driver's door; the driver-side rear door; the side wall in the region of the rear seat; the tank or the bumper; or on any other points on the body of the motor vehicle.

4. Anti-theft system according to one of the preceding claims wherein the phase control unit is realised by a shift register and a demultiplexer.

5. Anti-theft system according to one of the preceding claims, wherein the power control unit is realised by an up-counter and a comparator.

6. An anti-theft system for a motor vehicle

substantially as herein described, with reference to the accompanying drawings.

7. A motor vehicle incorporating the anti-theft system as claimed in any preceding claim.

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Application No:	GB 9825739.7	**Examiner:**	Catherine Schofield
Claims searched:	1-7	**Date of search:**	8 March 1999

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Other: Online:- WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2293200 A	(SIEMENS) - see particularly page 5, line 36 - page 7, line 4	
A	GB 2282252 A	(SIEMENS) - see whole document	
X	WO 98/50652 A1	(SIEMENS) - see fig. 4 and page 9, lines 4-12	1
X	US 4897644	(HIRANO) - see whole document particularly column 10, lines 33 - 46	1

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